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USSR: Computers

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SCIENCE & TECHNOLOGY

USSR: COMPUTERS

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UDC 51:681.3:007

Multilevel Structured Planning of Programs (Retrospective, Current Status, Prospects)

18630104A Kiev KIBERNETIKA in Russian No 4, Jul-Aug 88 (manuscript received 29 Apr 88) pp 34-41, 46

[Article by G. Ye. Tseytlin and Ye. L. Yushchenko]

[Abstract] The review of the Soviet lietrature discusses the past, current status, and future prospects of the method of multilevel structured program planning (MSPP), based on the system of algorithmic algebras suggested by V. M. Glushkov in 1965, drawn from studies conducted at the Institute of Cybernetics, Ukrainian Academy of Sciences, and other organizations. The essence of the method is multilevel planning of classes of algorithms and programs, based on the grammar of structured planning, a grammatical algebraic formalism combining the apparatus of the system of algorithmic algebras with mechanisms of parallel derivability developed in the theory of language processors. A "dialog with the readers" answers questions which arose during the course of scientific discussions of MSPP. References 45.

UDC 519.713.2

Converging Sequences of Automata

18630104B Kiev KIBERNETIKA in Russian No 4, Jul-Aug 88 (manuscript received 20 Feb 87) pp 53-57

[Article by P. V. Gorshkov and V. D. Frolov]

[Abstract] A definition is given for the concept of the limit of an automaton sequence, based on the concept of morphism of automata, a natural extension of the homomorphism of automata. The concept of morphism allows partial order to be established in a set of automata, induced by the relationship of inclusion of languages. Sufficient conditions are found for the existence of a limit in a sequence of automata and for interruption of the monotonic sequence of finite automata. The article also demonstrates the equality of the language

permitted by the final automaton in a sequence to the union of languages permitted by all the automata of the sequence. References 2: 1 Russian, 1 Western.

UDC 581.324

Algorithmic Language for Programming Multiprocessor Systems With Bus Structure

18630104C Kiev KIBERNETIKA in Russian No 4, Jul-Aug 88 (manuscript received 27 Apr 87) pp 66-70

[Article by R. I. Belitskiy, A. V. Palagin, and V. A. Petrov]

[Abstract] A description is presented of the Adamar language, a version of Ada for multiprocessor bus-structure systems, developed by the authors to program such systems. Adamar can describe parallel processes for various types of multiprocessor systems. The interaction of parallel processes is in keeping with specific features of bus-structure system architecture: each processor has its own memory in addition to common memory, all interprocessor interactions are based on exchanges through common memory with associative addressing, the basic set of event-awaiting operators is implemented in hardware and there is a single input-output processor. A six-pass cross compiler has been developed for the SM-2M computer, generating multimicroprocessor assembler-language output from Adamar source code. The number of parallel subroutines in a main program is limited to 255, while the total number of monitor packages is limited to 3839. Figure 1; references 11: 2 Russian, 9 Western.

UDC 519.8

Optimization of Multistage Cyclical Process of Transmanipulator Line Servicing

18630104D Kiev KIBERNETIKA in Russian No 4, Jul-Aug 88 (manuscript received 6 Apr 87) pp 95-103

[Article by V. S. Mikhalevich, S. A. Beletskiy and A. P. Monastyrev]

[Abstract] A solution is suggested to the multistage cyclical problem of transportation of products from processing machine to processing machine by a single transporter-manipulator with variable processing and transporting times. The solution is based on the method of branches and bounds. The algorithm suggested has been implemented as a PL/1 program. Numerical experimentation on a YeS 1033 computer demonstrated its practical applicability. Figures 3, tables 6, references 5: Russian.

Information Priorities: A Look Into Tomorrow

18630191 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian, No 88(5979), 15 Apr 89 p 1

[Article by G. Artamonov, doctor of technical sciences and professor at MAI [Moscow Aviation Institute]: "Information Priorities: A Look Into Tomorrow"]

[Text] A survey of information and computer experts by the Computer Center of the Academy of Social Sciences at CC CPSU indicated that, so far, 95 percent of the respondents see no radical change in informatization of society. Isn't this strange? Every year we produce several billion rubles worth of computer equipment and launch 50 automated management and information processing systems, and yet there is no progress.

Many people believe that the reason is a low saturation of the economy with computers. Usually, they cite the experience of advanced capitalist countries, especially the United States. Indeed, the United States now has 35 million personal computers alone, while the USSR has fewer computers by a factor of 300. It would be logical to expect that in our land highly scarce computer technology would be utilized extremely intensely. In reality, nothing of the sort takes place: most of the experts in the same survey testified that only a small part of the computer fleet is effectively utilized in the Soviet Union.

This happened because, regrettably, the informatization of society came to be understood as almost exclusively manufacturing computers, peripherals and software — essentially, the production of tools. On the other hand, when Western economists and sociologists talk of an "information society," that comes to supersede industrial society, they mean less the number of computer technological units per population than the stunning rate of growth of the amount of information produced and used by society. It is sufficient to recall that in the United States half of the entire labor force is now engaged in generation, dissemination and processing of all kinds of information! Certainly, handling this flow of knowledge without electronic technology is unthinkable. But, information is the primary element here. Society's need for speeding up and increasing information flows is what

drives the building of new computers, information networks, etc., rather than vice versa.

A market economy has been and still is built upon mutual interest — the interests of the seller and the buyer. Intense flow of goods and commodities is impossible without an intense movement of information: advertisement, technological, market and other information. Long before the first computers were built, the demand for rapid and exact knowledge was satisfied by fairs and exchanges: commodity, currency and stock exchanges. Now, in addition to them, the United States alone has 3300 generally accessible electronic databases covering almost all spheres of human activity. There is now talk of creating a global computerized information exchange network.

In the USSR, the elimination of the commodity and labor exchanges in the late 1920's and early 1930's stamped out the last foci of intensive information exchange. In a command economy, knowledge is driven not by the laws of supply and demand but by bureaucratic procedures: report from bottom to top and directives from top to bottom. The equal "seller-buyer" and "producer-consumer" relations have been supplanted by "benefactor-petitioner" and "boss-subordinate" relations. Participants of unequal economic relations are not interested in precise, complete and rapid mutual information. In fact, they are interested in hiding and blocking information: the lower "layers" do so to obtain a relatively comfortable existence; the higher layers to hide errors of management and retain their position as benefactor. As a result, information exchange ceases to be vitally important. Information flows circulating in society can be reduced or enlarged artificially at will by decision of a manager or depending on the situation. An upshot of this is stagnation in development of technology for information processing and transfer. This applies not only to computers: our printshops and telephone exchanges, our postal and transport communications are all hopelessly obsolete.

It is no accident that the time of the greatest successes in Soviet cybernetics was the era of the Krushchev "thaw," when many windows were flung open to the outside world. However, as early as the mid-1960's we began to feel a falling behind in information production. Those in positions of authority at that time saw the cause of this in an important but not primary fact: the poor reliability and standardization of Soviet computer technology. A program of national computerization which was aimed at copying Western hardware and software was born. This orientation is still in place.

Other attempts at copying others' decisions in information production were also made. In the late 1960's, for example, a decision was made to expand the network of shared-use computer centers — and create a national data transmission network. Announcements were made that common-access databases in science and technology would be built. Hundreds of national, Union-republic, regional and local institutes were founded for this purpose.

It would be wrong to say that these efforts were wasted. However, since the decisions were dictated by the will of authorities rather than by an economic need, the rate of return was low, and the Soviet Union fell behind in informatization even more. There are no data transmission networks except for narrowly departmental telephone networks. Isolated remote access databases are available to a few and operate on the basis of experimental sessions.

If we want to break out of the current situation, we must understand that information production is governed by the same economic laws as material production. The main law is that of supply of demand. Our disregard for this law in material production has caused us a lot of trouble. Therefore, any conception of national informatization should be aimed, above all, at encouraging conditions where a real rather than invented demand for complete and reliable information will be created. Such a demand will only appear after the economy is switched to market principles, to contractual relations among enterprises. For example, the development of wholesale trade should probably be promoted through the creation of a network of commodity exchanges and fairs. Each of these must become an independent self-financing commercial enterprise. They will not be able to exist unless they are tied into an integrated information network. This fact, without any decrees or programs, will force them to create such a network in the shortest possible time.

Leaving aside the purely economical aspects of the issue (although I repeat that without drastic changes in the economy any informatization problem will again go down the drain), such a concept should call primarily for conditions conducive to unobstructed circulation, search and processing of any desired information at any time of day. From this point of view, the efforts to saturate the end-users with computers appears false. They certainly need that technology, but it will remain dead unless there are effective channels for information transmission. At the same time, the country will simply not have enough means and forces to build information networks simultaneously in all industries. One should probably start with maximizing the use of existing networks. I refer specifically to the Ministry of Communications of the USSR.

There are 91,000 post offices in the country. Of these, 63,000 are rural. If, initially, the program is extended only to urban offices (which are linked by relatively stable communication channels and are located in industrial concentration areas) and each post office is supplied with at least one computer terminal operating round the clock, we will make a giant leap forward in building a unified national information network. That would require just 35,000 terminals, which is already feasible for Soviet industry.

The concept of national informatization should include priorities in the development of information flows in government agencies. From the point of

view of available resources, the first to be developed should be an information network servicing our transport. The MGA [Ministry of Civil Aviation] and MPS [Ministry of Railways] — our two main "carriers" — have a well-ramified network of their own. Furnishing it with computer technology can be done faster and cheaper than in those fields where one would have to start almost from scratch.

Gradually, industrywide networks will merge into a unified informational infrastructure of the country. This orientation of the new concept of national informatization will indeed give us a chance to join the ranks of informationalized nations.

UDC 65.512.4.011.56-52:621

Concept and Problems of Algorithmization of Technological Control of Flexible Automated Manufacturing Systems

18630129a Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA TEKHNICHESKIKH NAUK in Russian No 5, Sep-Oct 88 (manuscript received 21 May 87) pp 14-18

[Article by I.Kh. Sitdykov, Mechanics and Seismic Resistant Construction Institute imeni M.T. Urazbayev, AN UzSSR [UzSSR Academy of Sciences]]

[Text] To a large extent a flexible manufacturing system must allow "the possibility of continuous improvement and fast set-up change for manufacturing of new products" (GOST [State All-Union Standart] 14.001-73 and GOST 26228-85). A flexible automated manufacturing system (FAMS) is characterized by predominance of technological equipment, jigs and fixtures set up and controlled manually or programmably. FAMS control (PC), including technological control (TPC), must be automated (ATPC).

A FAMS is created in cases of very complicated PC due to [1]: a broadened product mix, frequent (during the last three to five years) [2] product changes [3], and higher (sixfold on the average in the last 30 years) [4] complexity of manufactured products at the majority of enterprises in the machine building and instrument making industries.

A FAMS is implemented under conditions when resources (equipment, materials etc.) are limited. And technologically optimal results can only be achieved when using a certain optimum resource, the amount of which is insufficient for the entire production volume. This forces one to use technologically interchangeable resources (IR) in an appropriate group of IR (GIR) and results in a multialternative product manufacturing technological project (TP).

An optimum combination of TP alternatives (that correspond to I-resources in a GIR) is chosen in the process of operational production control (OPC). Hence the need to "solve problems of operational calendar planning ... at the technological control level" [5].

The main (base) TP alternative is described in full, and for additional alternatives, in the descending order from the optimum alternative, only differences between them and the main alternative are specified. In operational calendar production plans one should not specify the total number

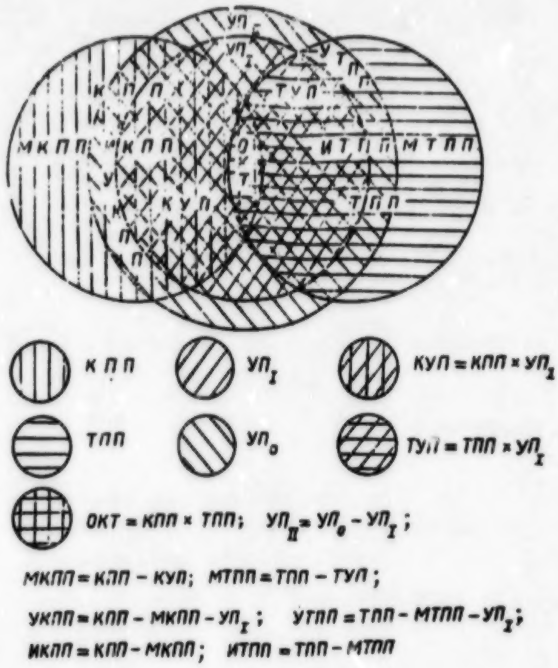

Figure 1. Hierarchic Relations of FAMS Information Support Processes: $УП_{0,I,II}$ - PC: general, 1st and 2nd level, respectively; КПП - design preparation of production [DPP]; УТПП - TPP [technological preparation of production] control; МКПП and ИКПП - material and information DPP, respectively; OKT - technological development of product design; ИТПП and МТПП - information and material TPP; УКПП - DPP control; КУП - design PC

of pieces, but numbers of pieces for each TP alternative, based on the optimum utilization of resources. For instance, when cutting blanks from a layout one should specify the number of blanks cut out in each layout alternative, based on optimum utilization of the material (initial blank). And the total required number of pieces must come out "automatically."

The multiplicity of TP alternatives, which is a requirement of a TP in an AOCS [automated operational control system] [1] is not taken into account in known SCADTP [systems for computer-aided design of technological processes] [6, 7]; there, one tries to derive a single optimum TP alternative.

A FAMS must be matched by a flexible system and organization of production and a flexible ACS [automated control system]. Importance of ATPC in FAMS increases, because FAMS have a heavier saturation of technological equipment than regular manufacturing systems.

The flexibility of an automated manufacturing system (AMS) is characterized by the length $\tau_{тпп}$ of the technological preparation of production (TPP) relative to period $\tau_{п}$ of stable product manufacturing $(\bar{\tau}_{тпп})$. For FAMS it can be assumed that $\tau_{тпп} \leq 1.5$ years and $\tau_{п} \leq 3\text{-}5$ years [3], therefore $\bar{\tau}_{тпп} \leq \frac{1.5}{5} \approx 0.3$.

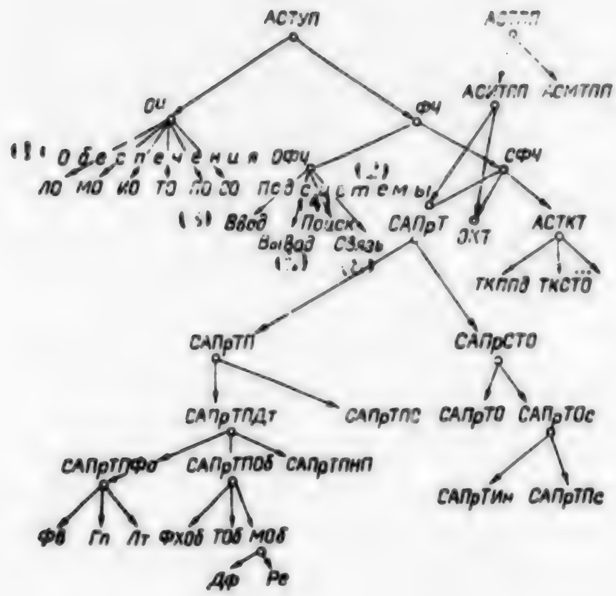

Figure 2. Hierarchic Structure of ASTPC and ASTPP:
ОЧ , ФЧ - supporting and functional services (SS and FS); ОФЧ and СФЧ - general and special FS; САПр - CAD system; Пр - design; ПрТ - technological design; ПрСТО - design of technological equipment, jigs and fixtures; ПрТП - technological design of production; Дт - part; ПС - manufacturing of subassemblies; Фо - shaping; Об - treatment, machining; НП - coating; Фв - forming; Гп - galvanoplastics; Лт - casting; ФХоб , ТОб , МОб - physicochemical treatment, heat treatment and machining, respectively; Дф - deforming; Pe - cutting; TO, TOc - technological equipment and technological jigs and fixtures, respectively; Ин - tooling; Пс - jig, fixture; ТКП - technological production control

Key:

1. Supports
2. Subsystems
3. Input
4. Search
5. Output
6. Link

The necessary degree of flexibility of AP can be achieved if the following supports are available:

1) material and technical support (of the so-called ancillary production, in the form of an automated system for material TPP - ASMTPP) of a fast new product MTPP (Figure 1);

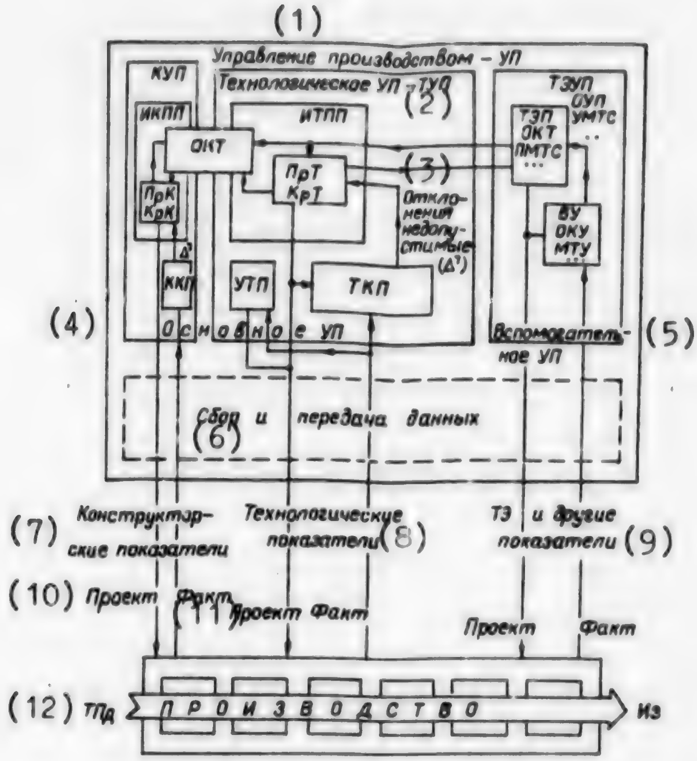

Figure 3. Information Links and Structure of TPC:
КУП - design PC; ТЭУП - technical and economic PC; YMTC - MTS [material and technical supply] control; ПМТС - MTS planning; ОКП - operational calendar planning; OKY, MTY - operational calendar and material and technical accounting, respectively; ПрК - developmental design; ТПд - objects of labor; Из - product; KpK, KpT - correction of КПк and ТПкп (design and technological, respectively); УТП - control of technological processes (in automatons)

Key:

1. Production control - PC
2. Technological production control - TPC
3. Intolerable deviations
4. Basic PC
5. Ancillary PC
6. Data acquisition and transmission
7. Design parameters
8. Technological parameters
9. Technical, economical and other parameters
10. Project
11. Actual
12. Production

2) information support (IS) in the form of an automated system (AS) for IS of FAMS (ASIS FAMS) that includes the following AS subsystems: information TPP (ASITPP) and TKP [not further identified] (ASTKP), which form TPC (ASTPC) and PC (ASPC) as a whole; their structure and hierarchic relations are shown in Figures 1 and 2. And the problem of creating an ASIS FAMS is coming to the forefront among other problems of creating an FAMS [8].

Following [5 and 9], one can identify the following information links and structure of TPC (Figure 3).

As any ASOC [1], an ASTPC must, unlike in the case of simply using computers for solving individual TPC problems, automate all levels, cycles, stages and problems of TPC. At the highest and lowest control level TPC can be strategic and tactical, respectively.

Strategic TPC includes the following three stages:

1) acquisition of information on the environment, i.e. source information for technological design of production (TDP), as well as on the product, resources etc.;

2) TDP, including the development of technological documents (TD) for production and control media - punch cards, tapes etc. - for CNC equipment;

3) transfer of TP, which obviously includes copying and mailing of design TD, training, consulting of performers etc.

During the second and subsequent control cycles TPC also consists of three stages:

1) TKP, i.e. acquisition and processing of information on the manufacturing system (including product quality and the status of resources), in order to determine conformity of the manufacturing system to the TP or the need to introduce control actions (GOST 16504-81 and GOST 16310-81);

2) developing (if necessary) control actions (CrT), usually in the form of TD change notices; in an ASTPC it is usually done by an algorithm, depending on the form of $\Delta^{\urcorner}$

3) delivering TP corrections to performers.

Tactical TPC also consists of three stages:

1) operational TKP, i.e. control of random (technological) variables (elements of technological procedures, time, labor content etc.);

2) in the case of $\Delta^{\urcorner}$, development of random values of control actions within the range of changes specified in the TP (see the second stage of strategic TPC);

3) manual or automated (semiautomatic or automatic) transfer of control actions, with the help of various communication facilities, to performers and/or actuating machines or mechanisms.

Usually [6, 7] one examines TDP problems and does not take into consideration the problem of acquiring information on the environment and TKP. As a result, local SCADTP, which do not form an ASTPC together with the ASTKP, are not being implemented in production. In real-life production TKP is performed, but it is not regulated and not organized, although some of its problems are being solved by the QC and Manufacturing Engineering Departments in the process of the CTD (control of technological discipline).

As other FAMS information support systems, an ASTPC must be flexible, i.e. lend itself to constant improvement. In order to achieve this, an ASTPC must be developed cybernetically, i.e. with automation (and optimization), using computers, in the form of a SCADTP ASTPC developed based on ideas of algorithmization [5]. A SCADTP ASTPC consists of six DB [databases], which together form (or represent) a standard ASTPC (StASTPC). A SCADTP ASTPC based on parameters of a specific production generates from the StASTPC a respective specific ASTPC (SpASTPS).

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UDC 62:40

Forecasting Technological Parameters in Continuous Production Processes

18630129b Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA TEKHNICHESKIKH NAUK in Russian No 5, Sep-Oct 88 (manuscript received 15 Oct 87) pp 18-21

[Article by B.A. Zakhidov, R.Kh. Ayupov and R.D. Salyamov, Uzbek scientific production association "Kibernetika", AN UzSSR [UzSSR Academy of Sciences]]

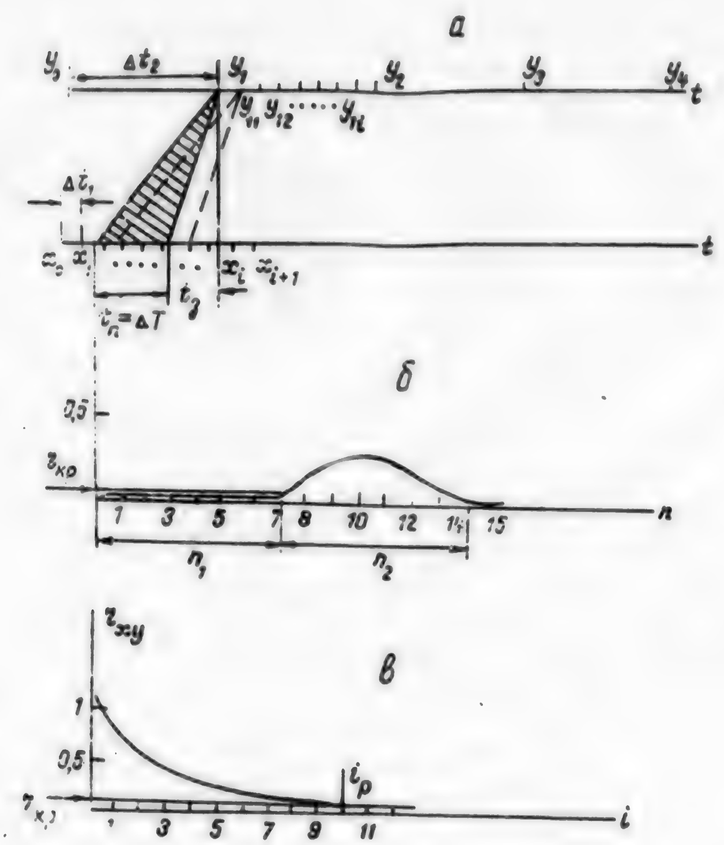
[Text] We shall select moments and lengths of intervals for measuring input x(t) and output y(t) variables for operational forecasting that takes into account specific features of technological processes, and construct a forecasting algorithm as it applies to real-life cases.

We shall study a process with one input and one output. Let a sample of input variables x_i measured with discretization interval Δt_1 and output variables measured with discretization interval Δt_2, wherein $\Delta t_2 \gg \Delta t_1$ (because the value of the output variable is measured in a laboratory as a result of fairly long experiments), be specified. The problem is reduced to developing an algorithm that makes it possible to derive the output variable with a discretization interval corresponding to that of input variable Δt_1. To do this, one must determine the moment when the formation of the array of input variable Δt_1 starts and the length of interval ΔT of measuring the array with the number of measurements equal to $\Delta T/\Delta t_1$, in order to reliably forecast output variable y_i. Formation of the output variable from the input variable can be presented schematically as shown in Figure a.

Only those values of the input variable that are present in the corresponding time interval ΔT, participate in the formation of values of the output variable.

In order to derive Δt and ΔT, necessary for forecasting output y_i from measurements of inputs x_i we shall plot the curve of the dependence of twin correlation coefficient r_{xy} on shift n of data array x_i relative to data array y_i, i.e. $r_{xy}(n)$. The calculations result in the curve (Figure δ). Using this curve one can derive time lag $t_з = n_1 \Delta t_1$ and object memory time $t_п = n_2 \Delta t_1$, which define the desired intervals:

$$\Delta t = t_з, \ \Delta T = t_п.$$



Using these data, we shall write the forecasting model:

$$Y=\sum_{i=n_1}^{n_1+n_2} a_i x_i, \qquad (1)$$

Model parameters a_i are estimated from the following adaptive algorithm:

$$a_i(N)=a_i(N-1)+\frac{Y(N)-\sum_{j=1}^{m} a_j(N-1)x_j(N)}{\gamma+\sum_{j=1}^{m} x_j^2(N)}\,x_i(N). \qquad (2)$$

Thus, construction of the forecasting algorithm includes the following principal stages:

1. One records input data x_i with discretization interval Δt_1 and input [exact translation] data with discretization interval Δt_2 under normal production conditions.

2. Using these data, one gradually shifts available input data relative to output data and calculates the above mentioned curve of the dependence of the twin correlation coefficient on the number of shifts $r_{xy}(n)$. Using this curve, one derives the desired intervals Δt and ΔT;

3. Taking into account Δt and ΔT, one constructs from the available set of data an observation matrix for each value of output variable y_i:

$$\begin{array}{l|llll} y_1 & x_{n1} & x_{n1+1} & \cdots & x_{n2} \\ y_2 & \dot{x}_{n1} & \dot{x}_{n1+1} & \cdots & \dot{x}_{n2+1} \\ y_3 & \ddot{x}_{n1} & \ddot{x}_{n1+1} & \cdots & \ddot{x}_{n2+1} \\ \vdots & \vdots & \vdots & & \vdots \\ y_l & x^l_{n1} & x^l_{n1+1} & \cdots & x^l_{n2+1} \end{array}$$

4. Using this matrix, one estimates parameters of a_i with the help of the method of least squares or any adaptive algorithm.

5. Using model (1), one forecasts output technological parameters with discretization interval Δt_1. If, for instance, one is forecasting y_{11}, then one substitutes as array x_i into model (1) input variables (shown dashed in Figure a) with the same interval Δt_1, which are measured at moments corresponding to a shift by one step forward ΔT;

6. Later, the model is corrected using algorithm (2) at moments when information on output variable y_i arrives from results of laboratory analyses.

The above method for constructing a forecasting algorithm is also applicable for objects with many independent inputs m. In this case, the forecast model is as follows:

$$Y = \sum_{j=1}^{m} \sum_{i=n_{1j}}^{n_{1j}+n_{2j}} a_{ij} x_{ij}, \qquad (3)$$

where n_{1j} and n_{2j} are defined independently for each input.

If input parameters of a process are interrelated, then instead of plotting curve $r_{xy}(n)$ one plots the curve of the dependence of the partial correlation coefficient on the number of shifts n, which makes it possible to isolate the relation between the output and an input parameter, while excluding the effect of other input parameters [2]. Formulas for calculating partial correlation coefficient for processes with two and three input parameters are as follows:

$$r_{x1yx2} = \frac{r_{x1y} - r_{x1x2} r_{yx2}}{\sqrt{(1 - r^2_{x1x2})(1 - r^2_{yx2})}}, \qquad (4)$$

$$r_{x1yx2x3} = \frac{r_{x1yx3} - r_{x1x2x3} r_{yx2x3}}{\sqrt{(1 - r^2_{x1x2x3})(1 - r^2_{yx2x3})}}. \qquad (5)$$

And one can exclude the variables that, after the effect of other variables is excluded, do not participate in the formation of output variable y, i.e. for which $r_{xyzs} < r_{\kappa p}(N, L) \forall n$. After deriving intervals Δt and ΔT for each input, we shall identify model parameters n_{1j} and n_{2j} and construct a forecasting algorithm from model (3).

If necessary, one can improve the accuracy of a forecast as follows. The values of the output variable with discretization interval Δt_1, which have been derived by forecasting using the above algorithm, are used to forecast the very value of the output variable. To do this, we construct the following data matrix:

$$\begin{array}{ccccccc}
y_{j-1} & y_{j-2} & y_{j-3} & y_{j-4} & y_{j-5} & y_{j-6} & y_{j-7} \\
y_j & y_{j-1} & y_{j-2} & y_{j-3} & y_{j-4} & y_{j-5} & y_{j-6} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
y_{j+k} & y_{j+k-1} & y_{j+k-2} & y_{j+k-3} & y_{j+k-4} & y_{j+k-5} & y_{j+k-6} \\
\hline
y & x_1 & x_2 & x_3 & x_4 & x_5 & x_6
\end{array}$$

Introducing the notation in the bottom column and using these data, we plot the curve of the dependence of twin correlation coefficient r_{xy} on the number of variables (Figure b) and derive the value of i_p, which is the number that defines the last element in time series y_j used for forecast Y_{j+1}. In this case the forecasting model is

$$Y_{k+1} = \sum_{j=1}^{m} \sum_{j=1}^{n_{1j}+n_{2j}} a_{ij}x_{ij} + b_1 y_k + b_2 y_{k-1} + \dots b_i y_{k-i_p}. \qquad (6)$$

A situation can occur when inputs of a technological process cannot be measured with sufficient accuracy due to the absence of reliable instruments. Then one can use an autoregression model

$$Y_{k+1} = \sum_{j=1}^{k} b_j y_j, \qquad (7)$$

for forecasting output parameter y_i. In this case, the summation limit k = = P, where i^p is derived from the above curve $r_{y_j y_{j-i}}(i)$.

Models of the (6) and (7) types can only be used when deriving curve $r_{y_j y_{j-i}}$, i.e. if there is a sufficiently strong correlation between several adjacent values of the output variable. And in these cases parameters of models (6) and (7) can be corrected gradually, using adaptive algorithms and specifying estimates based on old observations as initial estimates of parameters of the method of least squares.

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